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ONTARIO DEPARTMENT OF EDUCATION

CURRICULUM S-27C

INDUSTRIAL PHYSICS

FIVE-YEAR PROGRAM

GRADES 11 AND 12

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FOREWORD

This publication is a major revision of the Five-year Industrial Physics Course as outlined in Curriculum R.P.27. The span of subject content has been reduced considerably, and one new area, Instrumentation, introduced. As organized in its present form, the outline overlaps Grade 11 Physics, Curriculum S.17A, 1966, to a minor extent.

Industrial Physics is primarily concerned with physical principles as applied in industry. If students are to develop their understanding, they need "hands-on" experience with equipment that embodies these principles. If the emphasis is properly placed, the opportunity to work with suitable hardware will greatly enhance the students' ability to grasp underlying concepts.

Students of Industrial Physics will have considerable time available for laboratory activity. This is made possible by the scheduling of 10 periods per week in addition to the regular science periods in Grades 11 and 12.

The course has four Divisions: Mechanics and Materials, Fluids, Instrumentation, and Electricity. As such, it offers a broad look at industrial applications in these areas, and provides a good basis for further education in the theoretical and applied physical sciences. The teacher should stress the principles common to each Division. Students' useful knowledge and insight will grow when they note that the same concepts and laws are repeated in the various subject areas.

Based upon 10 periods per week, a total of 150 periods, plus or minus 20 per cent, is suggested for each Division. In addition to this flexibility, the teacher may omit the optional topics and substitute material which he deems more essential. As a guideline, estimated periods have been assigned to each unit, the letter "T" being used to indicate teaching periods and the letters "S.A.", student activity.

The teacher of Industrial Physics must have a genuine appreciation of applied physics. Industrial experience, as an engineer or senior technologist, is vital. Only a person with such a background can convey the excitement and power of creative technology to his students.

Instruction pertaining to Division Four will normally be given by the teachers of Electricity or Electronics in their shops. It is possible, however, that the teacher of Industrial Physics may be required to teach the whole course. Whatever the arrangement, Electricity should integrate with the other Divisions.

Since the Course is a two-year entity covering both Grades 11 and 12, the teachers must decide the extent to which any Unit will be studied in either grade. They must also determine the weekly and monthly sequence of topics because the Outline does not include any suggestion of optimum organization. Certainly any mechanical use of the material will result in a poor presentation.

A Curriculum Guide will be published shortly. It will expand the Outline in considerable detail.

OBJECTIVES

- To convey clearly many of the fundamental principles of physics.
- To provide a familiarity with some of the industrial applications of physical principles.
- To stimulate curiosity in the realm of science and technology.
- To serve as preparation for further education, particularly in the physical sciences.
- To encourage creative expression within the medium of science and technology.
- To develop problem-solving ability by means of exercises dealing with realistic problems of a technological nature.
- To instil a degree of confidence in the ability to comprehend, and work with complex industrial machines and processes.
- To teach some laboratory methods and techniques.
- To achieve a basic competence in certain technical areas of employment.
- To provide an overview of Canadian industry in order to make possible a selective orientation to the various areas of opportunity in technology.
- To acquaint the student with the sociological implications and effects of technology.

ORGANIZATION

Estimated periods: 150 \pm 30 per division

DIVISION 1 MECHANICS AND MATERIALS

- Units**
- 1.1 Introduction to Mechanics
 - 1.2 Dynamics
 - 1.3 Introduction to Statics
 - 1.4 Materials

DIVISION 2 FLUIDS

- Units**
- 2.1 Fundamentals of Hydraulics
 - 2.2 Hydraulic Components
 - 2.3 Hydraulic Circuits
 - 2.4 Fundamentals of Pneumatics
 - 2.5 Pneumatic Components and Circuits

DIVISION 3 INSTRUMENTATION

- Units**
- 3.1 Measurement and Indication
 - 3.2 Transmitting and Receiving Devices
 - 3.3 Analysis
 - 3.4 Control

DIVISION 4 ELECTRICITY

- Units**
- 4.1 Fundamentals of Electricity and Magnetism
 - 4.2 Electrical Devices
 - 4.3 Electronic Devices
 - 4.4 Circuits and Systems

DIVISION 1: MECHANICS AND MATERIALS

INTRODUCTION

This Division is intended to present to the student a general panorama of physical concepts related to mechanics and materials. Forces, their analysis and effects, are introduced, first in a general and elementary sense, then as applied to static equilibrium, and later in a more dynamic frame linking force with such concepts as acceleration, change of momentum, impulse, energy, and power. The treatment should, as far as possible, involve student activity with equipment, graphs, diagrams, and some meaningful problems. It is insufficient for students to learn them merely from textbooks, instruction sheets, and lectures. Much is left to the imagination and ingenuity of the teacher who will devise ways and means for his students to "experience" such physical concepts as force, acceleration, moment, momentum, equilibrium, work, and power.

The second half of this Division brings the student into closer contact with the applications of forces to actual materials. Deflection, strain, and stress are introduced repeatedly in an effort to allow the student to understand gradually the significance of these concepts by inquiry, discovery and discussion. These ideas should then merge into the more complex notions of moments of area, bending and twisting moments, and consideration of failure under load.

Finally, many properties of a number of materials may be examined. As selected properties are studied, measured, and altered, the student should be encouraged to think about possible explanations of properties and the criteria for the selection of materials in the industrial sphere of life. From all the many materials that may be selected for study it is strongly suggested that, at first, the quantitative measurements of various properties be undertaken on one basic material, such as steel. Once the student has been exposed to the types of properties that can be measured, and to the variety of measuring instruments, he can then investigate and compare the properties of other commonly used materials.

The teacher should be careful to avoid an overdose of heavy mathematics or involved explanations of the inner workings of measuring instruments. Many constructive ideas should be sought from local industries, good films and reference material.

UNIT 1.1

Total estimated periods for Division 1:

$$61T + 91SA = 152P$$

INTRODUCTION TO MECHANICS

11T 20SA

Types of Forces

Non-contact forces

Contact forces

Description of a force

Combined forces

Vector Analysis of Forces

Scalars and vectors

Combination of vectors

Turning Effects of Forces

Moments and couples

Principle of moments

Equilibrium of Forces

Free body diagrams

Conditions for equilibrium

UNIT 1.2

DYNAMICS

10T 22SA

Kinematics

Rectilinear motion

Curvilinear motion

Newton's Laws

The First Law

The Second Law

The Third Law

Momentum and Impulse

Dynamic Equilibrium (O)

Inertial forces in rectilinear motion

Inertial forces in curvilinear motion

Energy and Power

Work

Potential and kinetic energy

Power and Efficiency

UNIT 1.3

INTRODUCTION TO STATICS

24T 25SA

Tensile Force

Deflection

Strain

Stress

Interrelationships

Compressive Force

Deflection

Strain

Stress

Interrelationships

Shear Force

Deflection

Strain

Stress

Interrelationships

Area Relationships (O)

First moment of area

Second moment of area

Polar moment of area

Bending Moments

Deflection of a beam

Force-deflection relationships

Bending Stress

Shear force and bending moment diagrams

Twisting Moments

Origin

Deflection

Strain

Stress

Interrelationships

Failure Under Load

Static loads

Dynamic loads

Repetitive loads

Stress concentration

UNIT 1.4

MATERIALS

16T 24SA

Types of Properties

Density

Conductivity

Thermal

Surface

Mechanical

Measurement of Properties

Density

Conductivity

Thermal

Surface

Mechanical

Change of Properties

By composition

By heating and cooling

By mechanical processing

Explanation of Properties

Atomic

Homogeneous materials

Heterogeneous materials

Selection of Materials

Criteria for choice

Economics

DIVISION 2: FLUIDS

INTRODUCTION

Although energy transmission by means of a fluid medium is an old concept, many new specific applications are being employed in automated processes. The development of fluid logic apparatus promises to give further impetus to the fluid applications, since these components are easy to manufacture and trouble free in operation.

This Division is not meant to be an extensive fluid power study. It is hoped that the study of fluid properties will be channeled toward application rather than the reverse; for instance, the differing response rates for hydraulic and pneumatic systems should be explained on the basis of differing physical properties of oil and air, respectively.

The question of whether to teach pneumatics or hydraulics first is still not resolved. The teacher is free to start with pneumatics if he so wishes. If he chooses the other presentation order, he should spend a greater amount of time on pneumatics than suggested in the course of study. Once the fundamentals of pneumatics have been mastered, a correspondingly shorter time period needs to be spent on hydraulics.

Hydraulic pumps and motors, as well as air compressors, should not receive exhaustive treatment. In each case, one or two frequently occurring types should be examined carefully and reference to other types limited to operating principle only. In general, emphasis should be concentrated on efficiency of energy conversion rather than specific design features.

The use of high supply pressure is to be avoided. Hydraulic and pneumatic supply pressures less than 100 psi are quite enough for demonstration and experimentation in the laboratory, as brute force application is not being investigated.

The teacher is asked to make cross-reference to phenomena which occur in this Division but which have either direct application or analogy in other areas of study; for example, the one-way valve is the counterpart of the electrical diode since it allows only unidirectional flow. Through such cross-references the student will gain a knowledge and respect for the fundamental principles which govern our universe

UNIT 2.1

FUNDAMENTALS OF HYDRAULICS 15T 20SA

Introduction to Fluids

Historical Development of fluid mechanics

Liquids

Chemical Properties

Physical Properties

Hydrostatics

Pressure in a static fluid

Force multiplication

Fluid Dynamics

Continuity principle

Conservation of energy

Fluid flow

Forces on bodies immersed in moving fluids

Fluid-Dynamic Applications

UNIT 2.2

HYDRAULIC COMPONENTS 20T 21SA

Valve Construction and Operation

Pressure Control

Volume Control

Directional Control

Pilot operated

Actuators

Classification of types

Design Features

Pumps

Classification of types

Performance characteristics (O)

Motors (O)

Classification of types

Performance characteristics

Ancillary Components

Fluid conditioning, transport, and system sealing apparatus

Storage Devices

UNIT 2.3

HYDRAULIC CIRCUITS

5T 19SA

Analysis

Characteristics of Hydraulic Systems

Elementary Circuits

Advanced Circuits

UNIT 2.4

FUNDAMENTALS OF PNEUMATICS

4T 4SA

Introduction to Pneumatics

Physical Properties of Gases

Gas Flow (O)

Characteristics of Pneumatic Systems

UNIT 2.5

PNEUMATIC COMPONENTS AND CIRCUITS

16T 32SA

Air Compressor and Accessories

Positive displacement type piston compressor

Air storage and distribution system

Valve Construction and Operation

Directional control

Flow control

Sequence valves

Pneumatic Actuators

Linear

Rotary (O)

Circuits

Basic circuits

Advanced circuits

DIVISION 3: INSTRUMENTATION

INTRODUCTION

This Division includes the study of instrumentation in order to meet industry's increasing demands for personnel with a knowledge of industrial process control fundamentals. Since secondary schools offer very few courses in this field, most students are unaware of its opportunities.

The term "instrumentation" has a broad association within industry. In this course, its meaning is narrowed to include the measurement and control of flow, level, temperature and pressure as well as gas chromatography, spectrophotometry and pH analysis procedures.

In harmony with the aims of Industrial Physics, the teacher should try to give the student a clear understanding of fundamental principles rather than an extensive knowledge of specialized calibration procedures. Once he has mastered fundamental principles, the student will be able to extend his knowledge to more specialized manual applications. Hardware should thus be examined from a first principle basis with less emphasis on specific design characteristics.

Whenever possible, the student should concentrate on the numerous applications of control apparatus which can be found in his domestic environment. The automatic electric water heater is an excellent example of a closed loop temperature control system. The water closet is an example of a simple level sensing and control system.

Proportional control should be treated carefully. A superficial approach can do little to benefit the student whereas an in-depth study is above the Grade 11 and 12 level.

The teacher should not overlook the opportunity to refer to the extremely broad significance of basic principles. The concept of a time constant is associated with electronic circuits even though a thermometer exposed to a change of temperature exhibits the phenomena. Amplification, also a term usually associated with the field of electronics, also, interestingly, applies to pneumatic signal transmission devices.

In some areas of the province, there may be a local need for a more detailed coverage of this Division. Where this is the case, the teacher should make use of the time flexibility built into the Industrial Physics Course and expand the treatment of the Division accordingly.

UNIT 3.1

MEASUREMENT AND INDICATION 45T 61SA

Pressure

The physical nature of pressure
Primary measuring methods

Flow

Flow characteristics
Rate-of-flow meters
Total flow meters

Level

Direct liquid measurement
Indirect liquid measurement

Temperature

Changes in the physical properties of materials
Radiant energy

UNIT 3.2

TRANSMITTING AND RECEIVING DEVICES 8T 12SA

Pressure and Level Transmitters

Theory of operation
Design considerations
Calibration

Flow Transmitters

Differential pressure transmitters
Calibration

Receiving Devices

Universal recorders

UNIT 3.3

CONTROL
10T 10SA

Control Mechanics
Control system analysis
Modes of control (O)

UNIT 3.4

ANALYSIS
5T 5SA

Fluid Properties (O)
Viscosity
Ph
Gas thermal conductivity

DIVISION 4: ELECTRICITY

INTRODUCTION

Although this Division will normally be taught by teachers of Electricity and Electronics, it should be considered as an integral part of Industrial Physics. The participating teachers should coordinate their instruction so that the work done in Electricity supplements and reinforces the principles taught in the other Divisions.

Many concepts and principles appear in more than one Division; for example, conductivity, conservation of energy, vectors, power, sensitivity, amplification, feedback and time constants occur in Division 4 and elsewhere. These and other concepts can be clearly conveyed to the student if the teachers try to show inter-relationships between subject areas. Indeed, the basic aim of the course is only achieved if the students are able to see the repeated applicability of basic physical principles.

Unit 4.1 should be presented with particular care and thoroughness. The students must obtain a good grounding in electron phenomena and circuit analysis. The teachers of Electricity and Industrial Physics should agree on basic definitions, units and terminology.

The material in this Division is not arranged in a teaching sequence: it is an analysis of the subject matter, to be used as the teacher sees fit. Having introduced a topic from Unit 4.1, he may move to a related application referred to in another unit; or, he may discuss the properties of resistance, capacitance and inductance as part of the study of components (Unit 4.2) and then proceed to alternating current circuits (Unit 4.1). An infinite series of sequences are possible: the teacher should select those that appear to be logical and interesting.

Due to the limited time available, many legitimate topics have been omitted from the Outline. The teacher may wish to replace some of the optional topics with material that he considers more essential. Whatever the selected content, he should be keenly aware that the object of Industrial Physics is to convey basic concepts with the aid of suitable hardware: laboratory equipment is a means to an end, not an end in itself.

UNIT 4.1

FUNDAMENTALS OF ELECTRICITY AND MAGNETISM

38P

Electron Phenomena

Electron theory
Electrical charges
Electrostatic fields
Electrical potential

D. C. Circuits

Electrical conductors and insulators
Circuit analysis: Ohms Law, Kirchhoff's Laws
Power and energy

Magnetism

Theory of magnetism
Magnetic properties of materials
Magnetic circuits

Alternating Current Circuits

Scalar and vector quantities
Sinusoidal waveform
Non-sinusoidal waveforms
Purely resistive circuits
Purely inductive circuits
Purely capacitive circuits
L-C-R circuits, impedance
Power
Resonance

UNIT 4.2

ELECTRICAL DEVICES

44P

Basic Components

Resistors
Inductors
Capacitors

A. C. Machines

Transformer
Motors
Alternator

Measurement

D'Arsonval Galvanometer
Electrical bridges

UNIT 4.3

ELECTRONIC DEVICES

22P

Electron Emission

Vacuum diode

Vacuum triode

Vacuum pentode

Solid State

Diodes

Junction transistors

Field effect transistors (O)

Photo-electric Effect (O)

Photo-emissive

Photo-voltaic

Photo-conductive

UNIT 4.4

CIRCUITS AND SYSTEMS

46P

Rectifying Circuits

Half wave

Full wave

Smoothing filter networks

Silicon controlled rectifier (O)

Voltage doubler (O)

Amplifying Circuits

Voltage amplifiers

Power amplifiers

Feedback

Oscillators

Control Circuits (O)

Photo-electric

Voltage regulation

Motor speed

Test Equipment Systems

Electron Voltmeter

Oscilloscope

Signal generator (O)

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